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PASSIVE POWER DIVIDING NETWORKS

David John Carlson

There are many types of resistive splitters useable in power dividing networks. An application such as a VHF antennaplex distribution system causes many difficulties in the use of resistive splitters in that such a system requires minimum power loss, maximum number of output ports and a low standing wave ratio (SWR) at the multiple output ports.

Resistive power splitters may be considered in two general categories. The first is a division of power from one port of impedance Z_2 to N number of ports of higher impedance Z_1 i.e. Z_2 to $N Z_1$. The second category is division of power among N number of ports of equal impedance Z_1 , i.e. Z_1 to $(N-1) Z_1$.

A resistive power divider arrangement in the first category is shown in Figure 2 in which Z_1 and Z_2 are given and $Z_1 > Z_2$. The basic minimum loss pad formulas, as applicable to the arrangement of Figure 1, were

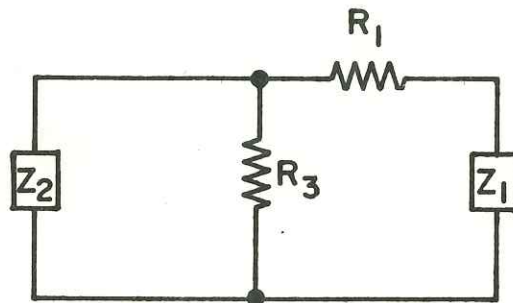


FIG. 1 BASIC MINIMUM LOSS PAD

modified to an N port output of Figure 2. For the resistor R_3 in the basic formula, a new value R_n is substituted. R_3 equals the parallel combination of $(N-1)$ additional output ports of the type $(R_1 + Z_1)$ and

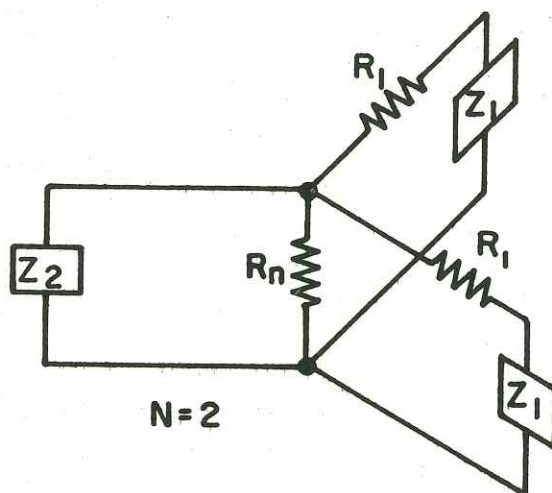


FIG. 2

the value of R_n . A summary of the equations for the parameters of the arrangement of Figures 1 & 2 are as follows:

Basic Minimum Loss Formulas (Fig. 1)

$$R_1 = Z_1 \sqrt{1 - \frac{Z_2}{Z_1}}; \quad R_3 = \frac{Z_2}{\sqrt{1 - \frac{Z_2}{Z_1}}}$$

Modified Minimum Loss Formulas (Fig. 2)

For $N = 1$; $R_n = R_3 = \frac{Z_2}{\sqrt{1 - \frac{Z_2}{Z_1}}}$

For $N \geq 2$; $R_n = \frac{Z_2}{\sqrt{1 - \frac{Z_2}{Z_1} - \frac{Z_2 (N-1)}{(R_1 + Z_1)}}$

Loss Z_1 to Z_2 :

$$\text{Power Loss (db)} = 10 \text{ Log} \left[\left(\frac{R_3 + Z_2}{R_3} \right) \left(\frac{R_1 (R_3 + Z_2) + R_3 Z_2}{R_3 Z_2} \right) \right]$$

Loss Z_1 to Z_1 :

$$\text{Power Loss (db)} = 10 \text{ Log} \left[\left(\frac{R_1 + Z_1}{Z_1} \right) \left(\frac{R_n Z_2 + (R_n + Z_2)(R_1 + Z_1)}{R_n Z_2} \right) \right]$$

$$\left(\frac{R_1}{Z_1} \right) \left(\frac{R_n Z_2 + (R_n + Z_2)(R_1 + Z_1)}{R_n Z_2 (R_1 + Z_1)} \right)$$

A resistive power divider arrangement in the second category, which exhibits somewhat more than the theoretical minimum power loss but is less sensitive to terminating conditions, is shown in Figure 3. For a

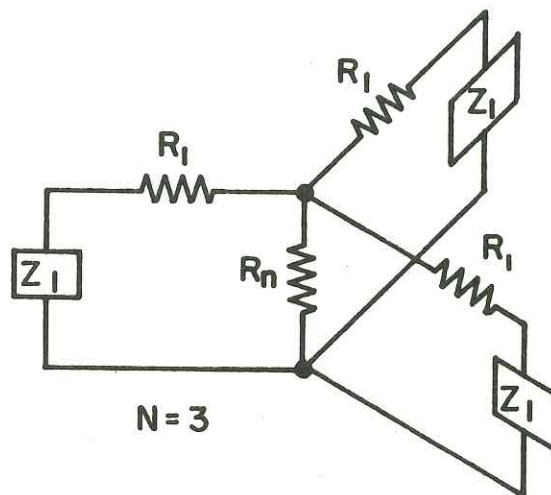


FIG. 3

divider of the type of Figure 3, where $N = 3$ for example, the maximum standing wave ratio (SWR) is two (2), but improves rapidly for larger values of N . A summary of the equations for the parameters of the arrangement of Figure 1 as modified in Figure 3, in which the value of Z_1 is given and is equal to Z_2 , are as follows:

Basic Minimum Loss Formulas (Fig. 1)

$$R_1 = Z_1 \sqrt{1 - \frac{Z_2}{Z_1}}; \quad R_3 = \frac{Z_2}{\sqrt{1 - \frac{Z_2}{Z_1}}}$$

Modified Minimum Loss Formulas (Fig. 3)

Substituting $Z_2 = \frac{R_1 + Z_1}{(N - 1)}$ and solving;

$$\text{then } R_1 = \frac{Z_1}{2(N - 1)} \left[\sqrt{4(n-1)(N-2) + 1} - 1 \right]$$

$$R_n = 2(R_1 + Z_1) \left[\frac{1}{\sqrt{4(N-1)(N-2) + 1} - 1} \right]$$

$$\text{Power Loss (db)} = 10 \text{ Log } \left[(N-1) \left(1 + \frac{R_1}{R_3} + \frac{R_1(N-1)}{Z_1 + R_1} \right) \left(1 + \frac{R_1 + Z_1}{R_3(N-1)} \right) \right]$$

A tabulation of the parameters of the arrangements of Figures 2 and 3 are given in Tables I and II respectively, for various example values of Z_1 , Z_2 and number of ports N . The values for R_1 and R_2 in Tables I and II are for standard resistance values.

TABLE I
Z₂ to N Port Z₁

Z₂ PORT 50 OHMS TO N Z₁ PORT 75 OHMS

R1	RN	N	SWR AT		DB LOSS	
			Z2	Z1	Z2 TO Z1	Z1 TO Z1
39	82	1	1.00678	1.05807	5.42717	0
39	330	2	1.02871	1.06467	5.52158	10.9151

Z₂ PORT 50 OHMS TO N Z₁ PORT 300 OHMS

R1	RN	N	SWR AT		DB LOSS	
			Z2	Z1	Z2 TO Z1	Z1 TO Z1
270	56	1	1.01981	1.01209	13.2718	0
270	56	2	1.0683	1.0161	13.6482	27.0045
270	68	3	1.00155	1.01294	13.3499	26.7063
270	82	4	1.04098	1.01113	13.1839	26.5404
270	82	5	1.04835	1.01522	13.5641	26.9204
270	100	6	1.02632	1.01423	13.4701	26.8265
270	120	7	1.0307	1.01443	13.4889	26.8453
270	150	8	1.03509	1.01463	13.5076	26.864
270	220	9	1.01675	1.01379	13.429	26.7854
270	390	10	1.0054	1.01326	13.38	26.7364
270	1200	11	1.00658	1.01332	13.3851	26.7415

Z₂ PORT 75 OHMS TO N Z₁ PORT 300 OHMS

R1	RN	N	SWR AT		DB LOSS	
			Z2	Z1	Z2 TO Z1	Z1 TO Z1
270	82	1	1.01641	1.03497	11.5253	0
270	100	2	1.01316	1.03287	11.6526	23.2472
270	120	3	1.01974	1.0324	11.681	23.2755
270	150	4	1.02632	1.03194	11.7092	23.3038
270	220	5	1.0012	1.03389	11.5905	23.1849
270	390	6	1.01856	1.03512	11.5162	23.1106
270	1200	7	1.01672	1.03499	11.5239	23.1183

TABLE II

Z1 to (N-1) Z1 PortsN Z₁ PORT 50 OHMS

R1	RN	N	SWR	DB LOSS
22	82	3	1.06345	9.18491
33	39	4	1.01657	14.0719
39	27	5	1.02396	17.1558
39	22	6	1.02377	19.0582
39	18	7	1.06085	20.6777
39	15	8	1.08977	22.0723
39	12	9	1.11675	23.415
47	10	10	1.04374	25.1389

N Z₁ PORT 75 OHMS

R1	RN	N	SWR	DB LOSS
33	120	3	1.06775	9.2179
47	68	4	1.03523	13.6913
56	47	5	1.00401	16.7596
56	33	6	1.06225	18.9396
56	27	7	1.10178	20.5587
68	22	8	1.0479	22.5571
68	22	9	1.03816	23.4473
68	15	10	1.00954	25.0247

N Z₁ PORT 300 OHMS

R1	RN	N	SWR	DB LOSS
150	470	3	1.00719	9.48038
220	270	4	1.08521	14.0849
220	180	5	1.01528	16.7909
220	120	6	1.08808	19.0789
270	100	7	1.06239	21.2509
270	100	8	1.04961	22.2766
270	82	9	1.02708	23.5652
270	68	10	1.00931	24.731